§14. Progress in Potential Formation and Findings in the Associated Radially Sheared Electric-Field Effects on the Suppression of Intermittent Turbulent Vortex-like Fluctuations and Transverse Losses

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(1) *Three-time progress* up to 2.1 kV in the formation *of ion-confining potential heights* in comparison to those attained 1992-2002 is achieved (Fig. 1) for tandem-mirror plasmas in the hot-ion mode with ion temperatures of several keV.[1,2]

(2) The advance in the potential formation gives bases for a *finding of the remarkable effects of radially produced shear of electric fields* E_r, *or non-uniform sheared plasma rotation* $\Omega_r=E_r/(r_cB)$ *on the suppression of turbulent fluctuations* for the first time in GAMMA 10.[1,2] (Here, r_c denotes a radius mapped to the central-cell.) (2-i) Such a shear effect on the central-cell plasmas is highlighted visually by x-ray tomography diagnostics (Fig. 2); that is, spatially and temporally *fluctuated vortex-like structures are clearly observed* in plasmas produced by ICH alone [having a quite *weak shear*]. (2-ii) However, during the application of plug ECH into the ICH plasmas, an associated potential rise produces a *stronger shear* [E_r=several 10 kV/m^2]. In this case, *the disappearance of the turbulent vortices* on the basis of such a high-potential formation due to ECH is found in association with *plasma confinement improvement*. In fact, *the associated temperature rise and transverse loss suppression are observed*.[1,2]

(3) From the viewpoints of both (i) a *conventional* idea of higher and *better potential confinement in the axial direction* [i.e., E_Z effects] and (ii) the present *new finding of a turbulent vortex disappearance due to a strong radial electric shear* [i.e., E_r effects] *in the transverse direction*, simultaneously, such a high potential formation is found to play an essential role in providing stably improved plasma confinement both radially and axially.[1,2]

(4) *For the physics interpretations and control of such potential* [or the associated E_r or Ω_r shear] formation, the validity of our proposed theory of the potential formation is extendedly tested under the conditions with auxiliary heatings. The *data described above well fit to the extended surfaces calculated from our proposed consolidated theory* of the strong ECH theory (plateau formation) with Pastukhov's theory on energy confinement. The validity of the extension of our proposed physics mechanism encourages the future extendable scalability of potential formation having prospective *simultaneous* E_z *and* E_r *(or* Ω_r*) shear effects on confinement improvements*.

References

1) Cho, T. et al. Phys. Rev. Lett. **94** (2005) 085002.
2) Cho, T. et al. Plenary Invited Talk in the 5th International Conference on Open Magnetic Systems for Plasma Confinement (Novosibirsk, 2004).

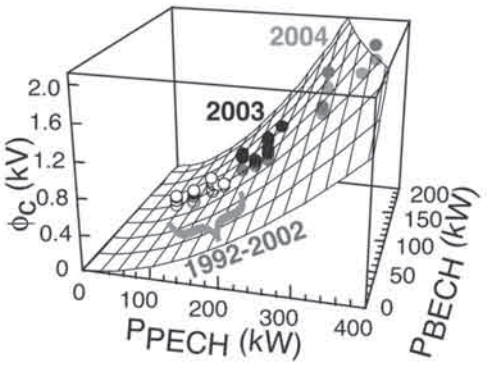

Fig. 1. Three-times advance in ion-confining potential (ϕ_c) formation including a record of 2.1 kV (filled circles), in comparison to ϕ_c attained 1992-2002 (open circles), is achieved. These extended data fit well to the scaling surface of ϕ_c with plug (P_{PECH}) and barrier (P_{BECH}) ECH powers. Here, a tandem mirror potential configuration with n_p/n_c=0.1 having T_i=several keV is employed.

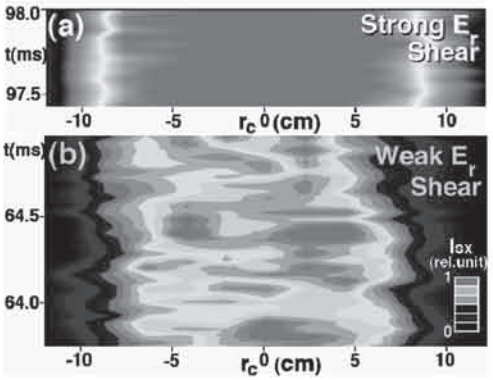

Fig. 2. Contours of central-cell x-ray brightness in the cases with (a) strong and (b) weak E_r shear formation. "Hot-colored areas" show higher plasma-pressure locations. Vortex-like structures are found in (b). The data are obtained by the use of our developed x-ray tomography systems. ($I \propto n_e n_i T_e^{2.3}$.)